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| **Lesson Title** | **Using Order of Operations to Evaluate and/or Simplify Expressions** |
| **Subject area/grade level** | **Mathematics Grades 5/6** |
| **Introduction** | A major focus of pre-algebra courses is the familiarize students with variable expressions. This lesson is a bridge between simplifying numerical expressions and evaluating algebraic expressions. |
| **Lesson Length** | 2 class periods (depending upon prerequisite knowledge and prior understandings) |
| **Materials** | Index cards  And (Loaf of bread, jar of jelly, knife, plate)  For *Order Please* one set of 5 number cubes per class; Order Please Chart for projector or board  TI-15 calculator (optional) |
| **Lesson Overview** | The lesson applies/extends the order of operations with practice in a game context. Together with property of substitution, the order of operations is used to evaluate a variable expression.  Online applets (NCTM Illuminations) and technology (TI-15) are employed to deepen understanding about substitution and evaluation of expressions.  **NCTM Principles and Standards for School Mathematics: Technology Principle** <http://www.nctm.org/standards/content.aspx?id=3448>  **Middle School Math and the Calculator (When to Use a Calculator)**  Dr. Louise Johnson <http://www.iched.org/cms/scripts/page.php?site_id=iched&item_id=math_calculator>  **Agenda for Action Recommendation 3:Technology**  <http://www.nctm.org/standards/content.aspx?id=17282> |
| **Tennessee Standards**  **MCS Power Standards** | **TN GRADE 5**  GLE 0506.3.1 Understand and use order of operations.  GLE 0506.3.2 Develop and apply the concept of variable.  GLE 0506.3.3 Understand and apply the substitution property.  SPI 0506.3.1 Evaluate algebraic expressions involving decimals and fractions using order of operations.  SPI 0506.3.2 Evaluate multi-step numerical expressions involving fractions using order of operations.  **MCS Grade 5**  Solve multi-step problems using whole numbers, mixed numbers, decimals and fractions. |
| **Lesson objective(s)** | The Learner will   * correctly verbalize order of operations * apply order of operations when simplifying/evaluating expressions * use correct notation to write a numerical expression * substitute a value for a variable in an expression using grouping symbols appropriately to retain order of operations * use technology with appropriate notation to evaluate expressions |
| **ENGAGEMENT**   * Describe how the teacher will capture students’ interest. * What kind of questions should the students ask themselves after the engagement? | |  |  |  | | --- | --- | --- | | Place students in groups to arrange index cards, each of which contains one step of an everyday process for which order of steps is unique. Before having students present the correct sequence, the teacher will choose one set of cards (building a house) and draw a picture on the white board of what it would look like if we did not follow the steps in order. For example, you can’t add a roof without walls being built first. | | | |  | Build a house |  | |  | Get materials  Make foundation  Build floor  Make frame for walls  Add roof  Add windows and doors  Add electrical lines/water pipes  Insulate walls  Cover wall studs with drywall  Paint walls |  |   NEXT,  Ask students to write down instructions to make a peanut butter and jelly sandwich; take them up and select one to follow. Follow instructions extremely literally and expect to make a mess. But take suggestions on how the directions should be amended to explicitly describe actions. Discuss “implied instructions” (such as, get bread implies you’ll have take the closure off the package, reach in and take a piece out) and “conventions” (such as putting jelly on bread requires spreading with a knife).  When does order of actions matter in math?  What kind of math problem has multiple steps?  How and when do we write action (operation) steps for computations?  Explain that we have need for these same types of communication and understanding in mathematics, i.e. there is an order to operations so that everyone gets the same value when evaluating a numerical statement.  Students will now watch a 5 min. video on the big screen from the following website:  <http://www.mathplayground.com/howto_pemdas.html> |
| **EXPLORATION**   * Describe what hands-on/minds-on activities students will be doing.      * List “big idea” conceptual questions the teacher will use to encourage and/or focus students’ exploration | Present one or more numerical/variable expressions including multiple operations and ask students to determine a number that they believe is the same as the given expression and to write that value on an index card to be handed to the teacher:  **Simplify 14 – 6 x 4 – 2 (20 ÷ 5 – 1) Evaluate 5ab2 – 4a/2 + b when a = 12 and b = 4**  Before you begin as a class to look at the values,ask students to make observations (record their observations on the board) about each expression one at a time and to make comparisons between them. Can they identify which is called a numerical expression and which is called a variable (algebraic) expression?  List class members’ values on the board. In case all the answers are correct, have a few cards ready with answers gained by incorrect order of operations so you can indicate the importance of all using the same “conventions” or order of operations. Ask volunteers to show how the value might be different depending upon which operation is performed first, second, third, etc.Conclude with the question: Which one is correct?  Students have some experience with order of operations. Ask students what order of operation rules they already know. Generate a list on the board.  Have students write down the order of operations using PEMDAS.  Follow up by adding precision to directions similar to how the directions to ‘make a jelly sandwich’ steps in process were clarified. For instance, if a student says MDAS, clarify M is not before D but that are done in the order in which they occur when moving form left to right in the expression.)  As a whole class or in small groups begin to develop a **Graphic Organizer for Order of Operations** that they have already experienced (flow chart, linear array, outline).  Ask: What about those expressions we have discussed is confusing to you? What do you see in this expression that isn’t covered by the rules we already know?  On the white board: Generate a list of issues not addressed by rules they already know (e.g. unknown operation symbols; grouping symbols; exponents; change in symbols to accommodate a variable changed to a numeral (substitution), etc.)  Big Idea: We need an order of operations that is consistent so we will know what value an expression has. |
| **EXPLANATION**   * Student explanations should precede introduction of terms or explanations by the teacher. * What questions or techniques will the teacher use to help students connect their exploration to the concept under examination? * List higher order thinking **(HOT)** questions which teachers will use to solicit *student* explanations and help them to justify their explanations. | Ask students to explain their understanding of terms: **evaluate, simplify**.  Generalize common notions.  Revisit problems:  Simplify 14 – 6x4-2(20÷5-1)  Evaluate 5ab2 – 4a/2 + b when a = 12 and b = 4  Deal with identified issues: unknown operation symbols; grouping symbols; exponents; change in symbols to accommodate a variable changed to a numeral (substitution), etc. Are there some “implied instructions” as discovered when making the jelly sandwich to operations implied by mathematical notation (i.e. m/5 means m x 1/5 or m÷5; implied multiplication: 3n means 3 times n and the number in a position like 3 is called a **numerical coefficient**; (4)(5) means 4 x 5) and “conventions” (i.e. writing coefficients before variables in a term, writing variable factors in alphabetical order.)  Summarize: What can we change or add to our (student generated) ‘order of operations list’ to establish a comprehensive set of rules?  Ask students for suggestions to refine order of operations **graphic**.  Apply caution when students say PEMDAS: identify and clarify issues inherent in the PEMDAS acronym for order of operations. Immediately use established order of operations to simplify the given expressions to one value.  Develop understanding of the term **expression**. (Concept card, Math journal vocabulary page) Add new terms as identified in lesson to Word Wall and incorporate them into word wall activities. (Training Handouts)  Student partners together on 2-3 practice problems (from text or board) while teacher circulates. |
| **ELABORATION**   * Describe how students will develop a more sophisticated understanding of the concept. * What vocabulary will be introduced and how will it connect to students’ observations? * How is this knowledge applied in our daily lives? | These activities give students practice writing numerical expressions using math symbols. Students develop strategies.  **Order Please?** From TN DOE Gateway Training Manual, Phase I (Game board handout)  In this activity, teams collaborate as they compete to be the first to cover four numbers in a row on a game board. Students will create a numerical expression that equals one of the numbers on the game board using a set of numbers gained from rolling three number cubes. Teams must present their CORRECTLY written and simplified expression before they can use their teams’ marker to cover a number.  **\*Students will use the following vocabulary words to develop illustrated flashcards. Students will be given blank index cards and will work in groups:**  Vocabulary (see use in examples): numerical expression, variable (algebraic) expression, numerical coefficient, evaluate, simplify; meaning of mathematical symbols, equality and equal sign, identity element for addition/multiplication. |
| **EXTENSION**  **INVOLVING TECHNOLOGY** | Have students determine if a scientific calculator or four-function calculator uses order of operations. Show students an example of each and then, using the ELMO and projector, demonstrate to students by inputing the same OOO problem into each, you get a different answer because the four-function does not do Order of Operations. Ask students to test different calculators they may have at home.  Students will use TI-15 calculators to practice OOO problems, while the teacher uses ELMO and projector to demonstrate using the giant teacher calculator. |
| **EVALUATION**   * How will students demonstrate that they have achieved the lesson objective? * This should be embedded throughout the lesson as well as at the end of the lesson | **S**tudents will demonstrate correct application in traditional format in board work, homework, quiz, warm-up in succeeding class.  **Alternative Opportunities for Evaluation:**  A. Practice with whiteboard/dry erase marker (provides immediate feedback.)  B. Centers: Students collaborate in pairs or small groups to complete one or more tasks at each center Select any of the following ideas or develop your own.   1. Task: Manual application of order of operations involving whole numbers 2. Task: Manual application of order of operations in problems involving fractions, decimals, or mixed numbers. 3. Task: Manual evaluation of variable expressions using substitution and order of operations. 4. Task: Using provided TI-15 calculators, check work from one of previous centers. Write about errors you discovered. 5. Task: Simplify expressions to decode answer to a riddle (see Algebra with Pizzazz)   C. Individual evaluation (Will be assigned as extra practice for homework):  *Order Me Please* (handout) |